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Date of Birth: May 10, 1984.
Citizenship: United Kingdom, Finland.

Education

Graduate Student: 2007-present

PhD, University of Manchester (expected completion September 2011).

Degree: 2003-2007

MPhys, first class honours, University of Manchester.

Research at the DØ experiment

Physics analysis

Z boson production: transverse momentum distribution and forward-backward asymmetry;

ZZ and WZ production in multi-lepton plus missing transverse energy final states.

Algorithm work

Electron and photon energy calibration, and modelling of the calorimeter response in Monte Carlo;

Studies of electron energy response in the inter-cryostat region of the calorimeter;

Muon track momentum smearing.

Operations

Data acquisition shifts.

Tevatron magnet alignment measurements.

Publications and talks

Selected publications

1. M. Vesterinen, T. R. Wyatt, *A Novel Technique for Studying the Z Boson Transverse Momentum Distribution at Hadron Colliders*, Nucl. Instr. and Methods in Phys. Res. A602:432-437 (2009).

2. A. Banfi, S. Redford, M. Vesterinen, P. Waller, T. R. Wyatt, *Optimisation of variables for studying dilepton transverse momentum distributions at hadron colliders*, arXiv:1009.1580 [hep-ex] *accepted by EPJ* (2011).

3. J. M. Butterworth *et al.*, *The Tools and Monte Carlo Working Group Summary Report from the Les Houches 2009 Workshop on TeV Colliders*, arXiv:1003.1643v1 [hep-ph] (2010).

4. DØ Collaboration, V. M. Abazov *et al.*, *Precise Study of the Z/γ^* Boson Transverse Momentum Distribution in $p\bar{p}$ Collisions Using a Novel Technique*, arXiv:1010.0262 [hep-ex] *accepted by Phys. Rev. Lett.* (2011).

5. DØ Collaboration, V. M. Abazov *et al.*, *Search for Randall-Sundrum gravitons in the dielectron and diphoton final states with 5.4 fb^{-1} of data from $p\bar{p}$ collisions at $\sqrt{s}$ =1.96 TeV*, Phys. Rev. Lett. 104, 241802 (2010).

6. S. Dodelson, M. Vesterinen, *Cosmic neutrino last scattering surface*, Phys. Rev. Lett. 103, 249901 (2009); Phys. Rev. Lett. 103, 249901(E) (2009).

Conference presentations

Invitation to give a talk at talk at Rencontres de Moriond EW, La Thuile, Italy, March 2011.

Talk given at the Lake Louise Winter Institute, Lake Louise, Alberta, Canada, February 2010.

Poster presented at the Fermilab Users' meeting, June 2009 (winner of poster competition).

Talk given at Pheno 2009, University of Wisconsin, Madison, May 2009.

University seminars

Particle Physics Group at the University of Manchester, October 2010.

High Energy Physics Group at the University of Wisconsin, April 2009.

Particle Physics Group at the University of Manchester, June 2008.

Conferences and schools attended

Selected conferences and workshops

Physics at the high energy frontier the Large Hadron Collider project, The Royal Society, London, May 2011.

YETI 2011, IPPP, Durham, January 2011.

Soft Gluons and New Physics at the LHC, Manchester, UK, November 2010.

Institute of Physics annual high energy physics meeting, Lancaster University, UK, April 2008.

Schools

Cargese 2010: Physics at TeV colliders – From Tevatron to LHC, Institute for Scientific Studies in Cargese, Corsica, July 2010.

CTEQ Summer School, Madison, Wisconsin, USA, June-July 2009.

RAL High Energy Physics Summer School, Somerville Campus, Oxford University, September 2008.

Teaching at the University of Manchester

Class teacher for Foundation year physics, October-December 2010;

Workshop demonstrator for Programming in C++, February-May 2008;

Workshop demonstrator for Programming in C, October-December 2007.

Research summary [1]

Novel variables for Z boson transverse momentum [1,2,3]

The production of W and Z bosons at hadron colliders is considered to be one of the most powerful probes of QCD. In particular, the Z boson transverse momentum distribution is sensitive to quark and gluon radiation from the initial state partons, and any intrinsic motion of the partons within the colliding hadrons. Despite the large Z event samples at the Tevatron (around 1 million events), precise measurement of the transverse momentum distribution has been limited by uncertainties in correcting for detector resolution and efficiency effects.

Part of my PhD work involved proposing the measurement of alternative variables which are sensitive to the same physics, but relatively insensitive to detector effects [1,2]. Various variables were proposed along the lines of focusing on the lepton angles rather than their momenta to improve resolution; and the component transverse to the lepton directions to reduce correlation with isolation efficiencies. In Ref. [2], we propose an optimal variable, ϕ^*, which is determined exclusively from angles and hence has essentially perfect resolution. I played a large part in proposing, implementing, and defending a measurement of this variable at the DØ experiment (described in the following section). This measurement makes an enormous leap in precision, and is already igniting new theoretical interest in this long studied topic.

Early in the development of these variables, I discussed them with theoretical colleagues at the University of Manchester who were interested in QCD physics. This has been a fruitful collaboration producing many papers on both the experimental and theoretical side, and is continuing with new theoretical and experimental students joining recently.

One component in the calculation of ϕ^* is an approximate determination of the scattering angle in the dilepton rest frame, which we also suggest [2] for measuring more precisely the forward-backward asymmetry of Z events and weak mixing angle (another DØ analysis described later).

Many existing measurements of W and Z observables, including some of the Z transverse momentum distribution, have attempted to correct for experimental acceptance and the effects of photon radiation from the final state leptons. I was involved in studies which recommend against such practises [3], and I actively encourage any DØ analyses to follow these recommendations.

[1] This section makes references to the list of selected publications.

Measurements of Z boson production properties at DØ [4]

The first half of my PhD analysis has focused on Z boson production properties. Using the novel variables described in the previous section, I was able to study the transverse momentum distribution with unprecedented precision. The main challenges in this analysis were understanding the angular dependencies of muon and electron identification efficiencies. In particular, I modified the electron and muon quality cuts generally used in DØ analyses, in order to increase efficiency within the central calorimeter inter-module regions, and the gaps between the muon system modules. This measurement [4] of the ϕ^* distribution significantly improved on any previous measurements of the transverse momentum in the following respect: combination of dielectron and dimuon channels; order of magnitude increase in effective luminosity; binning in dilepton rapidity (of theoretical interest); huge reduction in systematic uncertainties in correcting for resolution and efficiency.

I have also been involved in a measurement of the forward-backward charge asymmetry in $Z/\gamma^* \rightarrow \mu^+\mu^-$ events, which can be interpreted as a measurement of the weak mixing angle. This measurement benefits from similar optimisation of the variables in order to reduce the impact of the relatively poor central track momentum resolution for muons. The main challenges in this analysis are understanding of any detector asymmetries (for example due to curvature biases), track momentum resolution and scale modelling, and theoretical uncertainties (for example parton distribution functions). Publication of this analysis is expected on the timescale of my PhD thesis.

Recently, I have been supervising a MSc student on a measurement of angular distributions in $Z/\gamma^* \rightarrow e^+e^-$ events. In addition, I am involved in a program of MPhys final year projects analysing $Z/\gamma^* \rightarrow \mu^+\mu^-$ events, which has been running since the start of my PhD, and has trained a large number of now PhD students, and is hoped to produce some public results later this year.

Measurements of electroweak diboson production at DØ

The second part of my PhD jumps from the relatively high rates of Z boson events, to the much smaller cross section electroweak diboson processes. I am working on a measurement of the cross section (times branching ratio) for the $p\bar{p} \rightarrow ZZ \rightarrow ll\nu\nu$ and $p\bar{p} \rightarrow WZ \rightarrow l\nu ll$ processes. The challenges are somewhat different to the high statistics measurements of Z boson production; for instance the control of instrumental backgrounds due to mis-reconstructed missing transverse momentum, or jets mis-identified as leptons. Compared to previous analyses of these channels, I have relaxed selection requirements, studied additional control regions, and optimised some of the variables used to reject instrumental backgrounds. These improvements are in addition to a large increase in analysed luminosity. I expect to publish this analysis on the timescale of my PhD thesis.

Electron and photon identification at DØ [5]

The liquid argon and uranium calorimeter is one of the great successes of the DØ detector design. However, the Tevatron Run II upgrade, whilst allowing a significant increase in delivered luminosity and slight increase in energy, produced some unwanted degradation of the DØ calorimeter performance. The increased bunch crossing frequency lead to incomplete charge collection for electromagnetic (EM) showers; especially in the inter-module regions of the central calorimeter where the electric field is non-uniform. Until recently, most analyses excluded these regions of the calorimeter (covering roughly 20% of the central calorimeter acceptance) due to the poor energy measurement and efficiency. I proposed the idea of correcting for these energy losses, and studied correlations with shower shape variables. I thus achieved significant improvements in the electron and photon energy resolution. In addition, I developed a greatly improved treatment of the smearing applied to the Monte Carlo (which otherwise overestimates the resolution compared to data). Previous versions had been unable to describe the non Gaussian tails in the resolution. I implemented and commissioned the above improvements, together with updated cell level calibrations and simulation of cell energy saturation in the MC. All DØ analyses involving electrons and photons have since benefited in terms of sensitivity and accuracy. An example DØ analysis which utilised these improvements is a recent search for high mass dielectron and diphoton resonances [5].

A large fraction of the geometric acceptance of the calorimeter (separating central and forward cryostats) is insufficiently instrumented for EM cluster reconstruction. Many genuine electrons traversing this region actually get reconstructed as tau leptons, some of which can be later recovered as so called "ICR"-electrons, by using multivariate tools. Since the energy measurement for these electrons is not well studied, kinematic analysis has been based on the central track momentum. I proposed exploring the possibility of utilising the calorimeter information in combination with the tracker. Using an optimal combination of calorimeter and tracker information, together with a calibration of the calorimeter energy scale, I achieved significant improvements in resolution. After deriving an energy smearing prescription, the MC accurately describes the resolution in data. These improvements are expected to benefit the few analyses already using ICR-electrons, and even allow/encourage others to start including them.

Muon identification and tracking at DØ

It has long been observed that the simulation of the DØ detector predicts an over-optimistic central track momentum resolution. A smearing prescription derived using the $J/\psi \to \mu^+\mu^-$ and $Z/\gamma^* \to \mu^+\mu^-$ line-shapes has long been used to alleviate this mis-modelling. I was involved in a recent effort to improve the smearing to better describe non-Gaussian tails in the resolution.

I was also involved in studies of curvature biases in both the central tracker, and local muon system. In particular, I validated methods to flip the solenoid and toroid magnet polarities in the detector simulation, as is done in the real detector periodically. These studies are of great importance to the electroweak charge asymmetry measurements.

Using cosmic ray muon events, I made studies of the central track angle resolutions, and demonstrated some significant differences in simulation compared to data.

Cosmic neutrino last scattering surface [6]

It has long been assumed that compared to the last scattering surface of the cosmic microwave background (CMB), the equivalent neutrino surface (CNB) is *further* away from us, since neutrinos decoupled at the electroweak scale, whereas photons decoupled at around the electron mass. The CNB was briefly mentioned in a lecture by Scott Dodelson in a cosmology lecture at the 2009 CTEQ summer school in Madison, Wisconsin. This topic was raised again in a late night question session, and I asked Scott Dodelson whether this picture changes significantly when considering the mass of neutrinos (i.e. the neutrinos travelling slower than photons). It turns out that when this previously overlooked detail is taken into account, the CNB LSS is actually predicted to be *closer* than the CMB LSS for any reasonable (given current constraints) neutrino mass. If we are to one day observe these neutrinos directly (remains an experimental dream for now), their interpretation is thus changed. This paper was published in Physical Review Letters [6], and highlighted in the October 2009 Physical Review Focus.

Postdoctoral research plans

After completion of my PhD, I plan to move from the Tevatron to work in experiment operation and data analysis at the LHC. I see this as an excellent opportunity to become involved in the exciting LHC program, and learn new detector technologies and experimental methods that complement those that I have worked with at the Tevatron. During my PhD work, I have become an expert in the identification of electrons and muons, and the reconstruction of W and Z boson events. I have also gained significant knowledge in the field of QCD phenomenology using these electroweak processes, thanks largely to collaboration with theorists in the Manchester group.

I now wish to expand my horizons and use other experimental methods; for instance the reconstruction and calibration of jets, and B tagging of jets. I would be very excited about doing such physics at the ATLAS or CMS experiments, perhaps applied to new physics searches with B jets and missing transverse energy.

Another area that I have recently followed with interest (both inside and outside DØ) is B physics; particularly rare decays of B mesons. Studying this physics on the LHCb experiment would be of great interest to me. I am also interested in the dedicated particle identification technologies in the LHCb detector, which are not used in DØ.

References

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